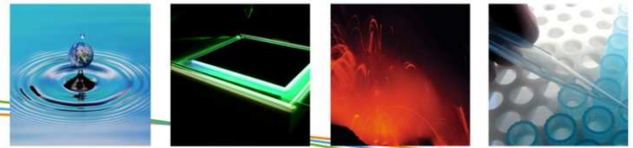


16/05/2011

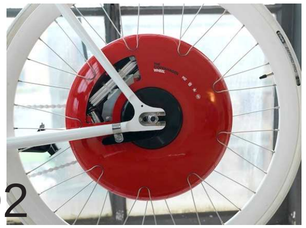
The potential of community science for outdoor air quality monitoring

IoT for a Sustainable Future

Vielsalm, 9 – 13 May 2011

MAQUMON
O3, NO2, CO/VOC

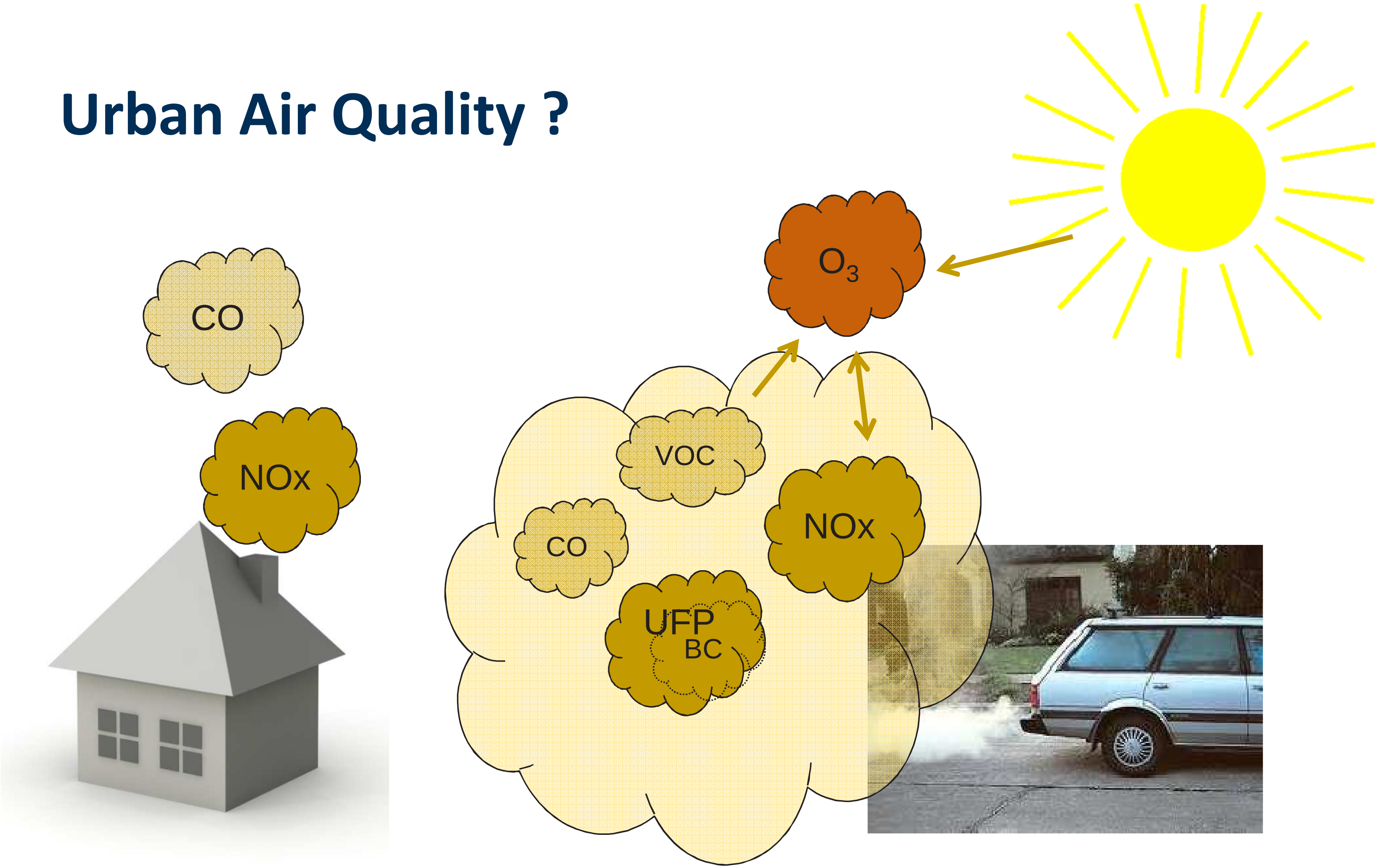
Common Sense
CO, NOx and O3



Copenhagen Wheel
CO2, CO and NO2

SenSaris SensPod
CO and NO2

Urban Air Quality ?



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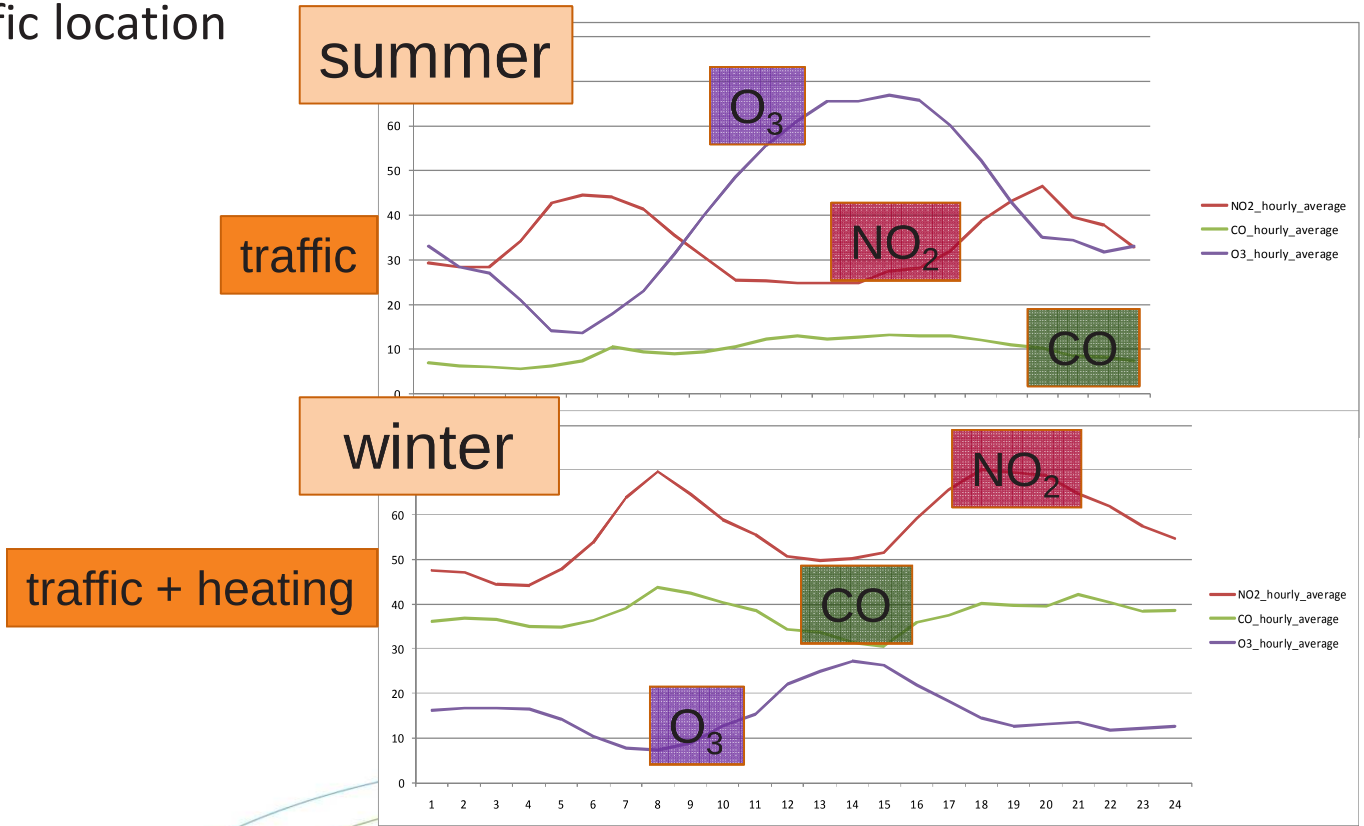
Urban air Quality ?

- complex mixture: NO2, O3, CO, VOC, PM10, PM2,5, UFP, …
  - different diurnal and seasonal trends
  - different sources
- E.g.: urban traffic location

µg/m^3
ppb



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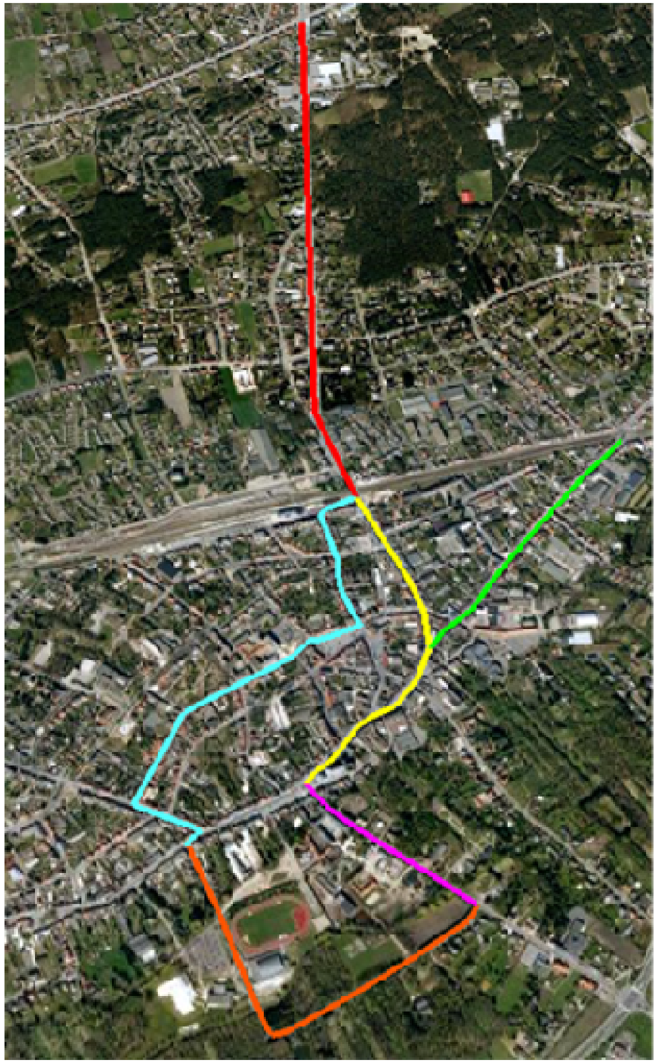
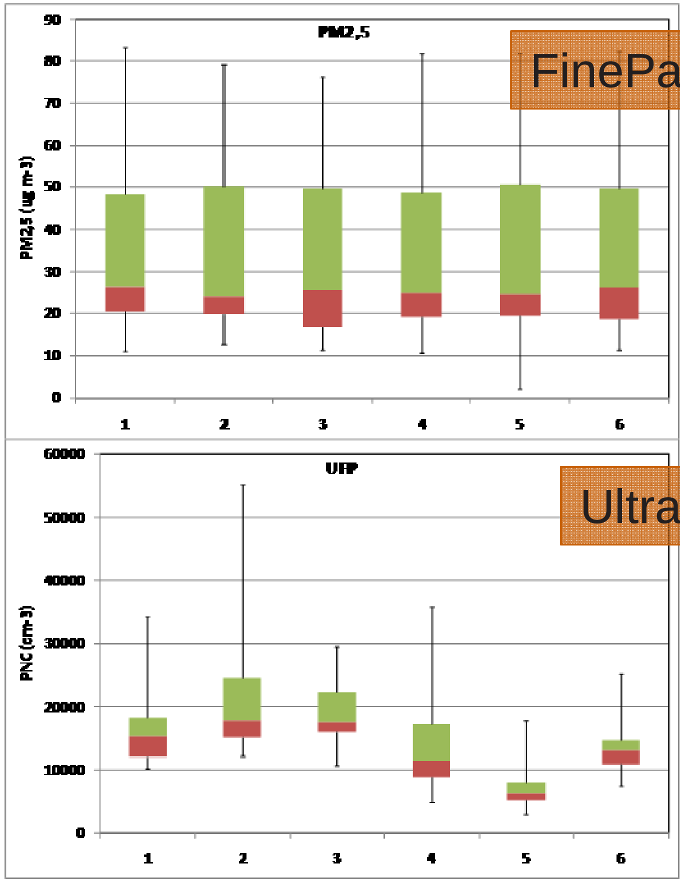
Urban Air Quality ?





FineParticles PM2.5

UltraFineParticles

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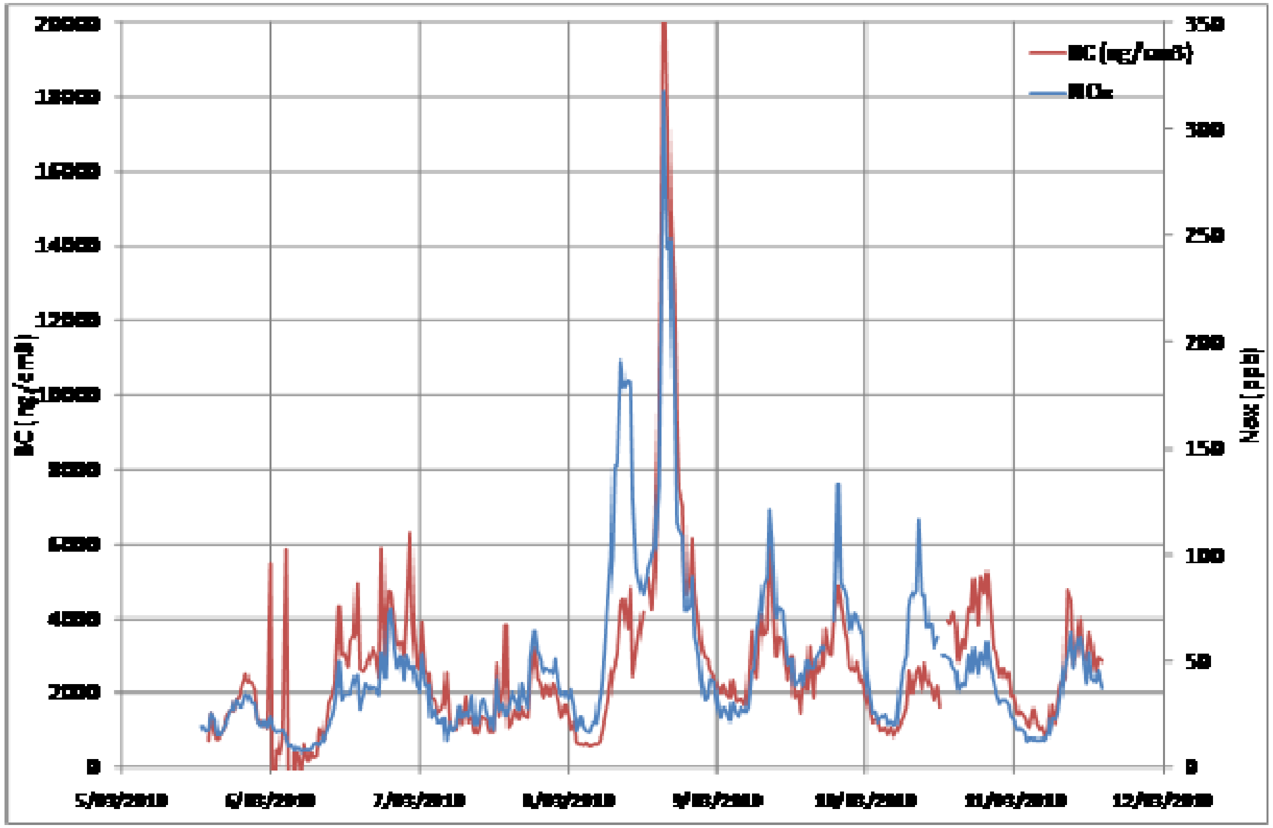
Urban Air Quality ?



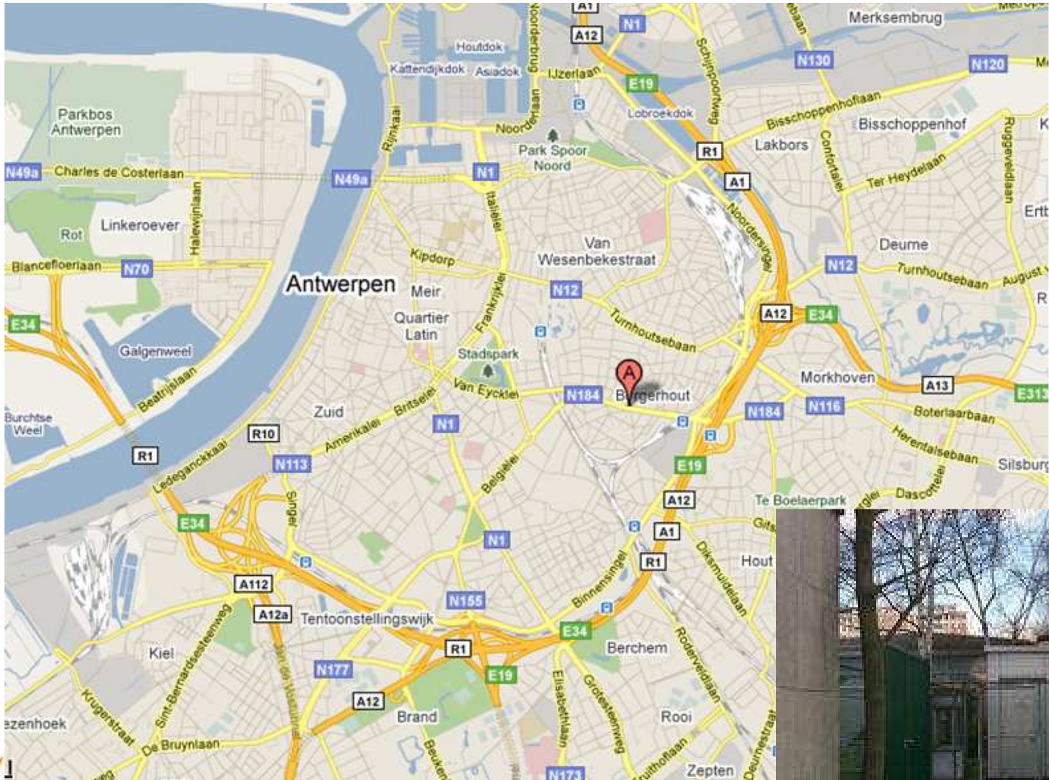
BlackCarbon and NOx concentrations near Districthuis in Antwerp

Air Quality Monitoring: why ?

- Legislation (EU Air Quality Directive)
  - normally based on assumed negative effects / risk analysis (human, ecosystems)
  - but: relations exposure - health not yet properly understood
  - lagging behind: new insights – improved measurement devices
- Health
  - Exposure
  - Poorly regulated components
  - Non-regulated components

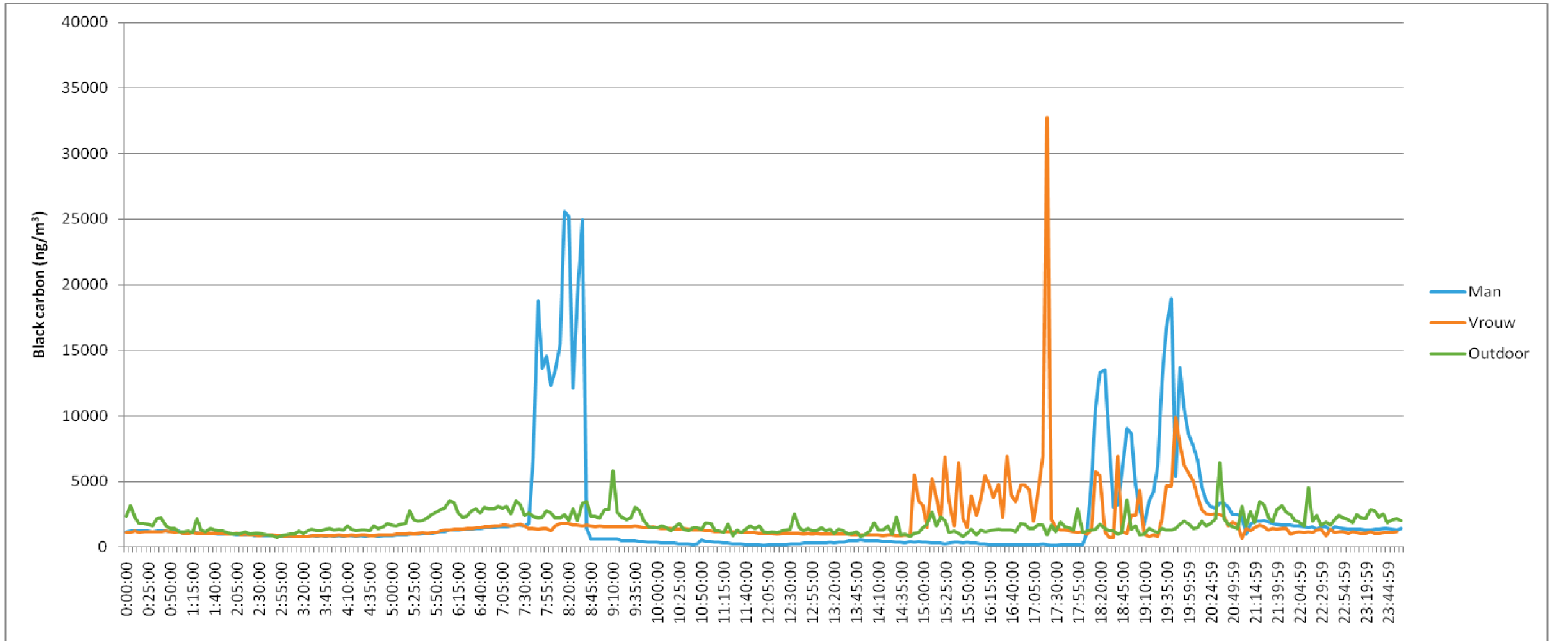
Air Quality monitoring: how ?

- Conventional: Reference methods
  - Only regulated components
  - “Correct” but poor spatial coverage

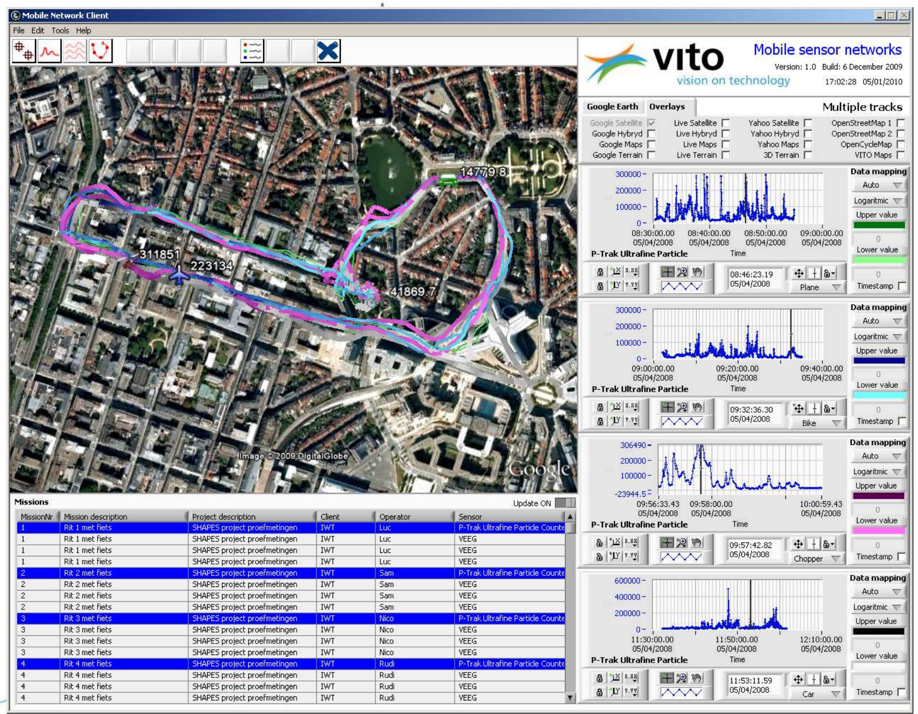


New approaches: focus on exposure and health

- health-relevance versus regulation
- exposure in different micro-environments
- portable devices



New approaches: mobile measurements



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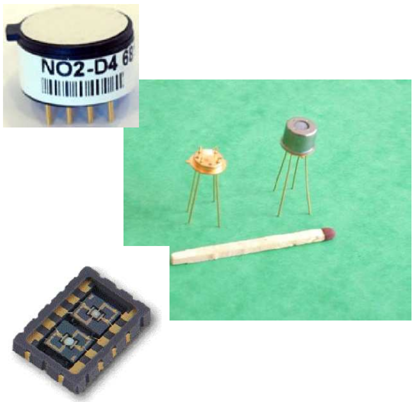
New approaches: Low cost gas sensors



Basic sensors

- Electrochemical
- Semiconductor metaloxide
- 5 – 80 €

Sensor head

- temperature control
- calibration curve
- correcting for T, RH
- 200 - 300 €

Measuring device

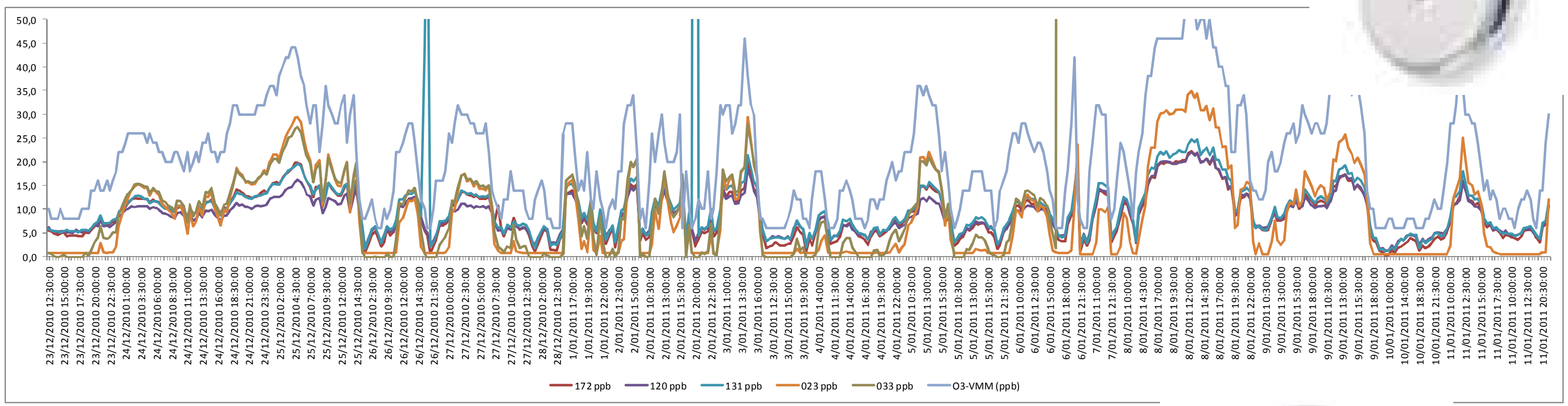
- 1000 - 2000 €

Not designed for / little experience in ppb range

cross-interference, drift, T and Hum effects

Metaloxide gas sensors: adapted for ppb

- Aeroqual: O_3 - 300 €
  - sensitive layer
  - temperature+air flow modulation,
- Aeroqual: NO_2 - 1500 €
  - O_3 scrubber

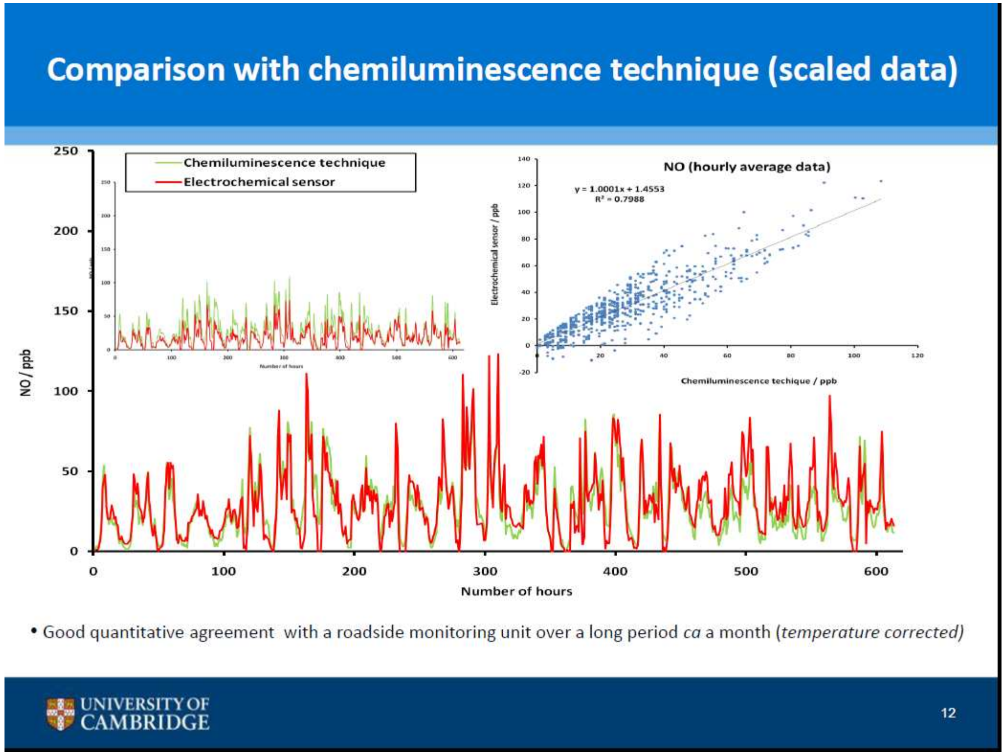


- UniTec: NO_2, CO – 2000 EUR
  - poor results: own tests; JRC-Ispra (O_3)

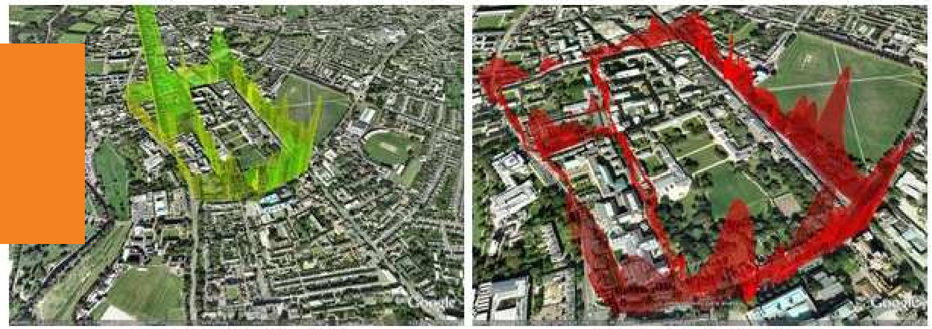
Electrochemical sensors: adapted for ppb

» **Cambridge University**

MESSAGE project
Alphasense electrochemical
sensors: CO, NO2 and NO
GPS, Bluetooth



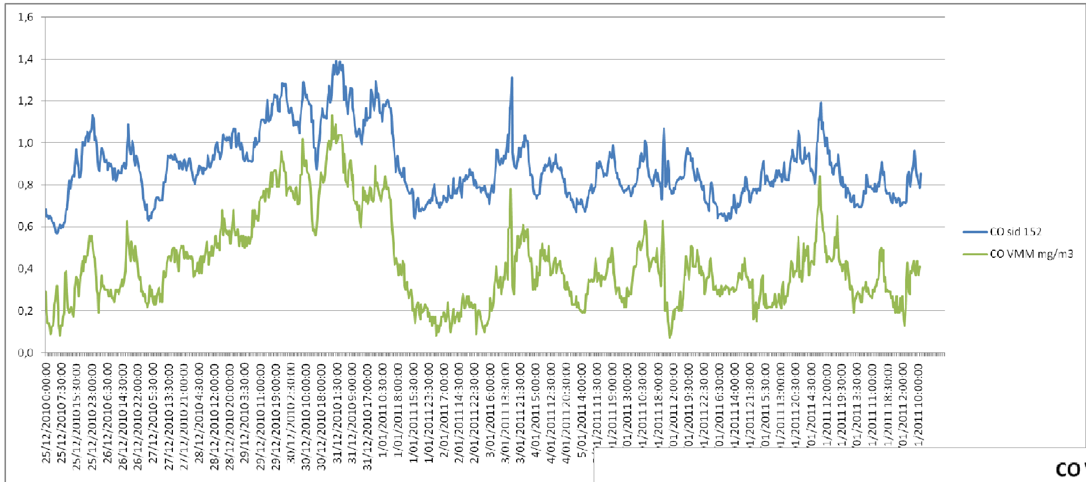
To be tested in the near future

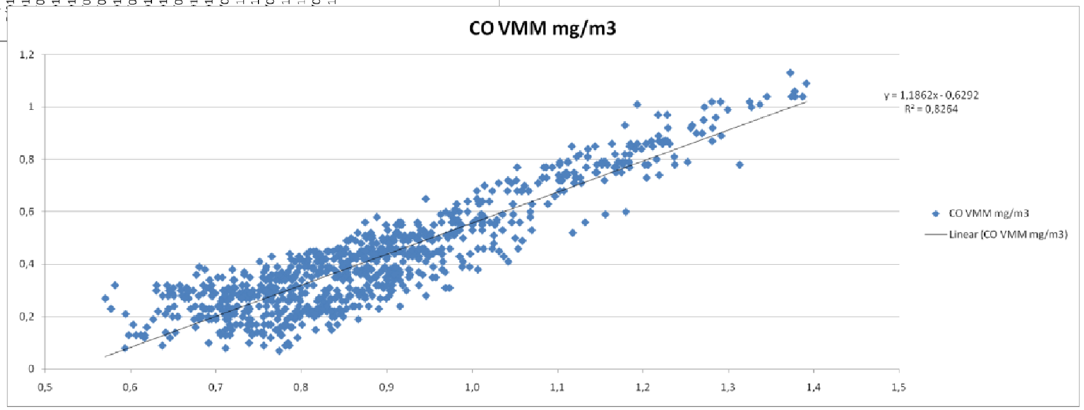


carbon monoxide (CO)   nitrogen monoxide (NO)

Electrochemical sensors CO

» Good correlation with reference measurements: R^2 = 0,83





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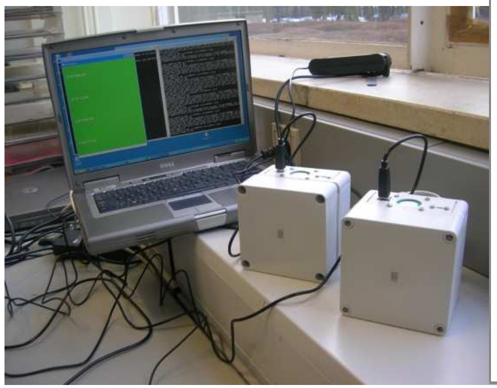
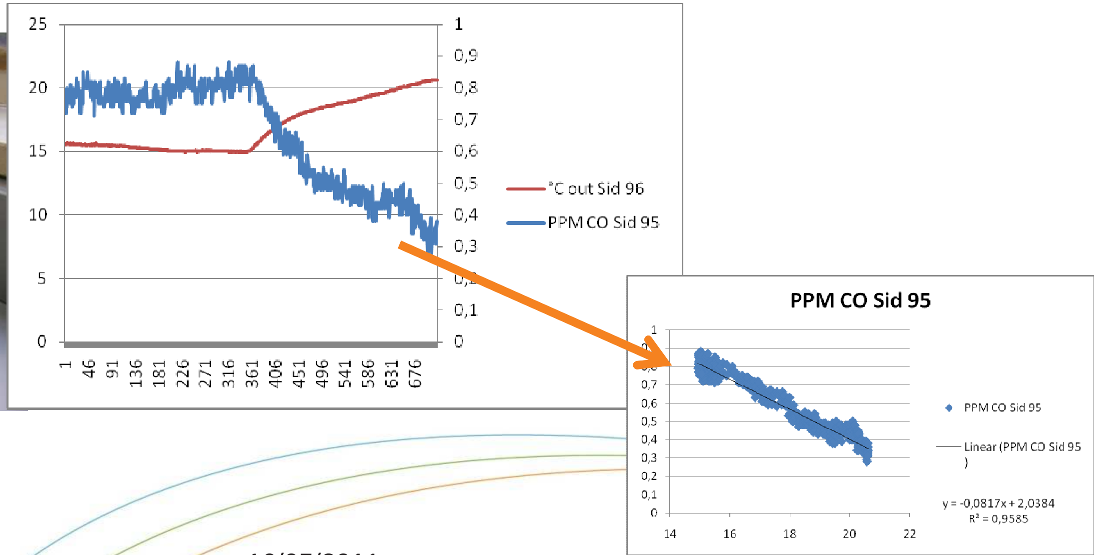
Electrochemical sensors CO

- Sensitivity changes with temperature
- Reaction on change of RH
- Zero-line (0 PPM) changes with changing temperature
- Sensor differences → selection

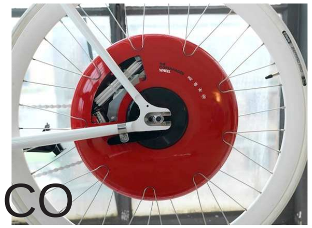




Lowest cost sensors

MAQUMON
E2V MiCS O3, NO2, CO/VOC

Common Sense
CO, NOx and O3



Copenhagen Wheel
E2V MiCS-4514: CO and NO2

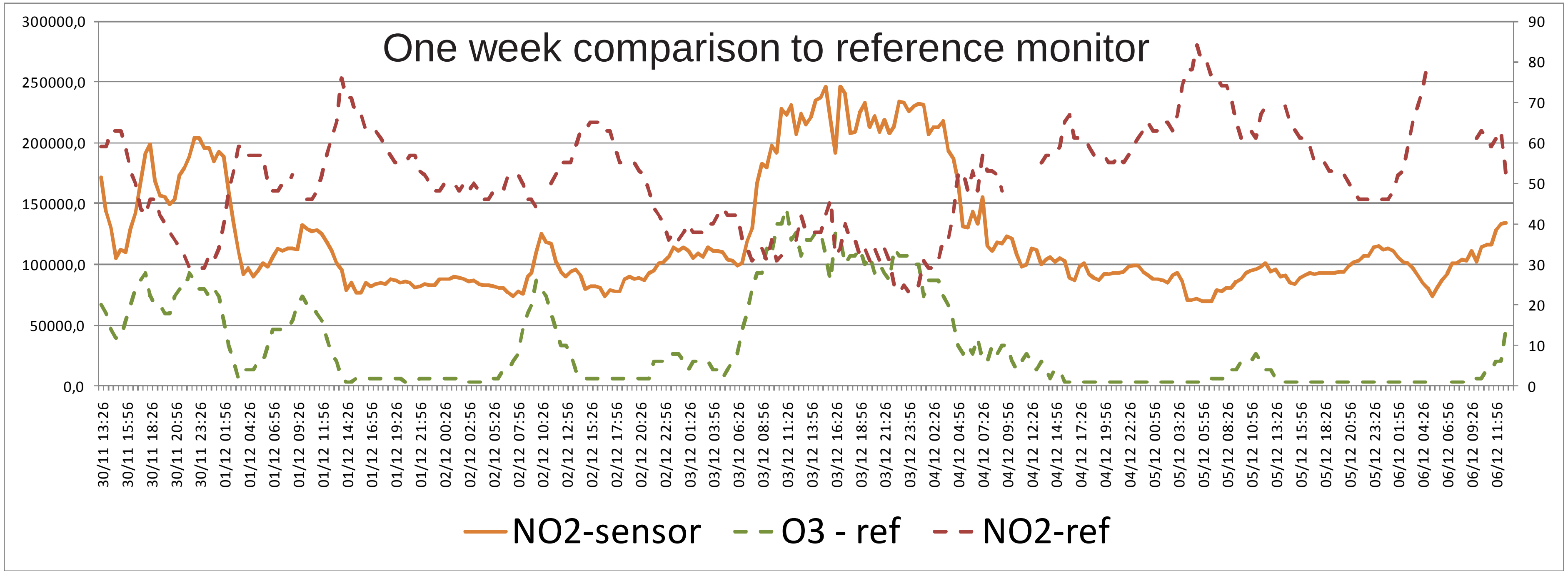
SenSaris SensPod
E2V MiCS-4514: CO and NO2

Lowest cost sensors: some initial results

E2V MiCS-4514: CO and NO2

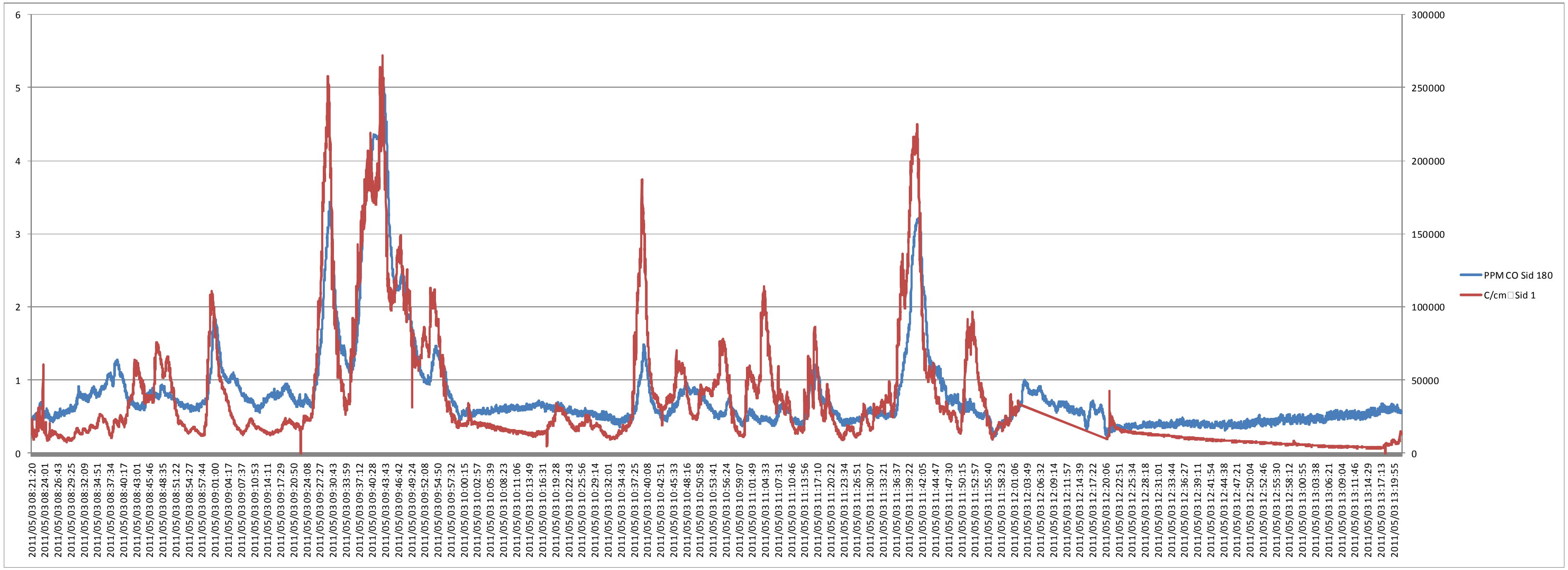
-What is it measuring ?
- Is it an O3-sensor ?
- Combined response ?

	NO2-ref	O3-ref	CO-ref
NO2-sensor 1	-0,65	0,82	-0,55
CO-sensor 1	-0,74	0,72	-0,61
NO2-sensor 2	-0,69	0,92	-0,55
CO-sensor 2	-0,74	0,85	-0,60
NO2-ref	1,00	-0,73	0,50
O3-ref	0,00	1,00	-0,57
CO-ref	0,00	0,00	1,00



Lowest cost sensors: some initial results

In car – 5 hours drive through Brussels



Micro-aethalometer Black Carbon

Electrochemical CO-sensor

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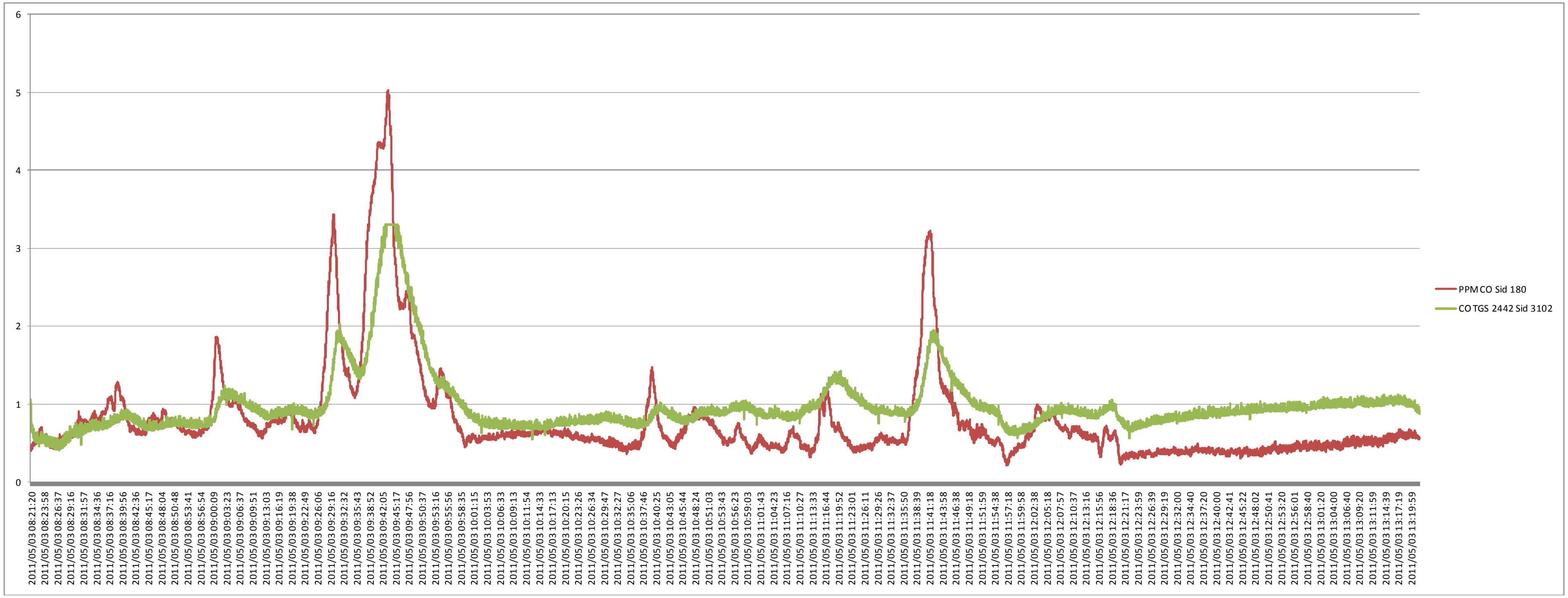
Lowest cost sensors: some initial results



Electrochemical CO-sensor

Metaloxide CO-sensor

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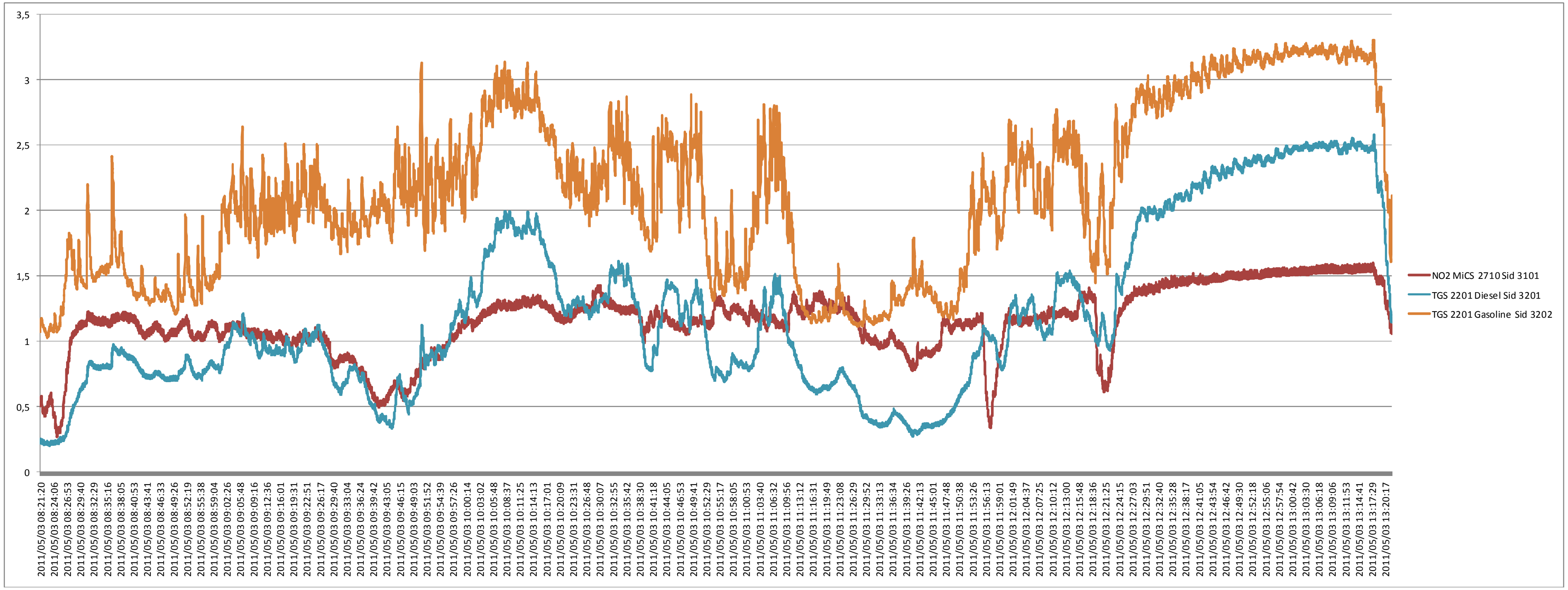
Lowest cost sensors: some initial results



Metaloxide NO2-sensor

Metaloxide diesel-exhaust-sensor

Metaloxide gasoline exhaust sensor

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Sensor arrays

- Exploit partial selectivity of sensors towards different components using neural networks, support vector machines, Gaussian regression for pattern recognition and multivariate calibration

Saverio De Vito, Marco Piga, Luca Martinotto, Girolamo Di Francia, CO, NO2 and NOx urban pollution monitoring with on-field calibrated electronic nose by automatic bayesian regularization, Sensors and Actuators B: Chemical, Volume 143, Issue 1, 4 December 2009, Pages 182-191

- Use available data
  - Existing AQM stations
  - Existing air quality models – real time predictions)
- Collect context (street lay-out, traffic intensity, …)
- Add other sensors (e.g. noise)

Conclusions

- AQ sensing not yet ready for pervasive applications / crowd sourcing
- Difficult to rely on a strategy with low-cost sensors only
- Combine low-cost sensors, more sophisticated sensors, AQ models, contextual information (human sensors)
- Need for a lot of "expert" knowledge to get from data to information
- Multidisciplinarity
- "Community Science" model
  - Citizen scientists – regular scientists – policy makers
  - Define research questions
  - Source available data and knowledge – don't start from scratch
  - Combine"expert" knowledge and citizen knowledge
  - Make it transparent
  - Roles dependent on available tools, research questions

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